REMARKS/ARGUMENTS

¶1. Claim 1 has been objected to for not having a comma after "plane" in line 11 and for having a period instead of a comma in line 14. Claim 1 has now been amended to remove these objections.

¶2. - ¶3. Claims 1-8 stand rejected under 35 U.S.C. 112, second paragraph, as being indefinite.

Specifically, the following portion of claim 1, lines 5-7, was found to be unclear:

"a pair of first and second apertured conductive disks forming a cage for said dielectric disk and mounted for rotation with the second half of said shaft said cage shielding portions of said spokes of said dielectric disk in proportion to applied shaft torque;"

The foregoing portion was unclear because of the absence of a comma between "shaft" and "said cage" in line 6. This rejection has been overcome with the addition of the necessary comma. This portion has been rewritten below with the insertion of the numbers from the figures for the convenience of the Examiner to better clarify this portion:

"a pair of first (18) and second (19) apertured conductive disks (18 & 19) forming a cage for said dielectric disk (16) and mounted for rotation with the second half (11B) of said shaft (11), said cage shielding portions of said spokes (17) of said dielectric disk in proportion to applied shaft torque;"

In addition, a portion of claim 1 starting on line 8 and containing the phrase "lying in a common plane" was found to be unclear.

The foregoing portion was also unclear because of the absence of a comma, which has now been added after the term "plane" to overcome this rejection. The entire portion has been rewritten below with the insertion of the numbers from the figures for the convenience of the Examiner in clarifying this portion:

"a pair of concentric capacitor plate rings (12 &13) lying in a common plane, one ring (13) having a greater diameter than the other ring (12) encircling said first half (11A) and

5

juxtaposed with said first apertured conductive disk (18);"

Finally, a portion of claim 1 at line 14 and containing the phrase "aid first shaft half" was found to be unclear.

The foregoing portion was also unclear because of a typographical error of "aid", which replaced with "said" to overcome this rejection. To complete the inclusion of the entire portion with reference to the numbers in the figures, the following is submitted for the Examiner's convenience:

"an opposed capacitor plate (10), encircling said second half (11B) and juxtaposed with said second apertured conductive disk (19); each apertured conductive disk (18 & 19) including apertures arranged in a pair of concentric rings (21 & 22) that match the first and second concentric plate rings (12 & 13), which encircle said first half (11A), said apertures alternating with solid conductive portions around a circle, said concentric rings (21 & 22) being offset from one another by 180 degrees so that at least part of the solid portion of one ring matches the aperture of the other to provide differential capacitances;"

The foregoing amendments to claim 1 along with the reference to the numbers in the figures are intended to clarify the Applicants' invention and to more clearly distinguish the presently claimed differential capacitive torque sensor from devices of the prior art. The basic distinguishing feature of the Applicants' claimed sensor is the insertion of a piece of dielectric disk (16) having a plurality of spokes (17) between a cage of conductive material in form of the two apertured conductive plates 18 and 19.

¶4. -¶ 5. Claims 1- 8 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Montagu *et al.* (6,218,803) in view of Kovacich *et al.* (6,442,812) and Takahashi (4,244,219).

Montagu *et al.* do not disclose nor suggest such a cage of conductive material. The differential capacitive sensor disclosed by Montagu *et al.* starting at col 6, line 1 and shown in FIGS. 1 and 2 is only a narrow angle sensor. Because of the orientation of the elements making up the Montagu *et al.* sensor, only angles of less then 90 degrees can be measured; see FIG. 2 of

6

Montagu *et al.* The Montagu *et al.* sensor does not measure nor is it capable of measuring the torque of a steering shaft with a torsion bar embedded in the shaft to divide it into first and second halves as in the Applicants' sensor that performs an angle measurement simultaneously with the rotation of the shaft. There is no suggestion in Montagu et al of dividing shaft 9 into first and second halves by means of a torsion bar.

Contrary to that suggested by the Examiner, the capacitive plate members 1, 2, 3, and 4, which are mounted on a stationary support plate 14, of Montagu *et al.* are not equivalent to nor function in the same manner as the pair of concentric capacitor plate rings (12 &13) where one ring (13) has a greater diameter than the other ring (12) as in the Applicants' sensor.

The Examiner recognizes that Montagu *et al.* do not disclose nor suggest the pair of first and second apertured conductive disks forming a cage for the dielectric disk. The Examiner cites Kovacich *et al.* to make up for this deficiency.

Kovacich *et al.* disclose and claim a piezoelectric torque sensor that is entirely different from the Applicants' differential capacitive torque sensor. The sensor of Kovacich *et al.* is based on crystal oscillator theory as shown by the electrical schematic of their system shown in FIG. 9. The representation of the capacitive portion of the invention claimed in this reference is shown on FIGS. 6 and 7. These figures clearly demonstrate that this design has no utility in detecting changes in capacity for small angles of differential rotation while maintaining that capacity, at a constant torque, through infinite revolutions of the shaft as the Applicants sensor is designed to accomplish. This is true because the differential angle that is created by the torsion member of the Kovacich *et al.* is considerably less than a degree. Comparing the torque sensor shown in FIGS. 6 and 7 of Kovacich *et al.* with the Applicants' FIG. 11, the Examiner can readily appreciate that one skilled in the art would not be able to combine anything disclosed in this reference with that disclosed in the Montague *et al.* reference to come up with the Applicants' differential capacitive torque sensor.

The Examiner has attempted to equate the first and second cylindrical electrode layers 142 and 144 that are respectively mounted on circular plates 144 and 148 with the Applicants' pair of first and second apertured conductive disks. There is nothing remotely similar between these pairs of elements.

7

The Examiner recognizes that the electrode layers 142 and 144 have no similarity to the Applicants' apertured disks and relies on the previously cited Takahashi reference for teaching disc members 23_1 and 23_2 that are bored at the center with apertures 23_4 and 23_5.

Although it is true the Applicants and Takahasi both use an apertured structure that can be found on any optical encoder design, Takahashi's invention is directed to a single variable capacitor as a detection element for the torque measurement. It is not even remotely based on the differential technique of the Applicants' claimed invention.

The Applicants sensor converts the differential angle between the first and second halves of the shaft that is the result of the applied torque to the torsion bar embedded into the shaft, not disclosed in any of the cited references, to a rotational movement of the dielectric element. This is shown in the Applicants' FIGS. 5-9. FIG. 8 shows the Applicants' sensor when the sensor is set to nominal and spokes 17 of dielectric disk 16 are half-way into the inner aperture of inner aperture ring 22 and outer aperture of outer aperture ring 21 of apertured conductive disks 18 and 19, the sensor is balanced and the output is in the mid range. Thus, this will provide equal values or balanced capacitances, C1 and C2, because of the equal areas of the concentric plate rings 12 and 13. The rotational movement of the first apertured conductive disk 18, caging the dielectric disk 16 with respect to the second apertured conductive disk 19, causes the change of capacitance of one capacitor plate rings, e.g. 12, to increase as the other ring, e.g. 13, decreases proportionately.

FIG. 9 illustrates a maximum torque situation (for one rotational direction), where the inner apertures are only minimally covered by spoke 17 and the outer apertures are provided with maximum coverage by spoke 17. The cage of conductive disks 18 and 19 serves to shield spokes 17 from the opposed capacitor plates (see FIG. 2) and will have no influence on the capacities C1 and C2. Thus, the capacities are modified as the spokes move out of the confines of the shielded portion of the cage and into the apertures of the cage. FIG. 9 shows the outer ring 13 having the maximum capacity because the dielectric spoke 17 is substantially unshielded and the inner ring 12 having the minimum capacity because it is substantially shielded.

The present invention not only satisfies the basic variable capacitor equation, but also results in a ratiometric output. The presently claimed invention is a completely non-contacting

8

design. It is unlike other similar sensors in the prior in having no slip-rings or ribbon cable for power or signal, that should mean that it has unlimited life. The output of the sensor of the present invention can be computed by the equation $(C1-C2)/(C1+C2)$ where the capacitance C1 occurs between plate opposed capacitor 10 and the outer concentric ring 21 and the capacitance C2 occurs between the plate 10 and the inner concentric ring 22. The output of this sensor is proportional to the change in angle between the first and second halves of the shafts that is the result of applied torque. The output signal is also stable through the environment (temperature, humidity, etc.) due to the ratiometric structure and inherent common mode rejection of the two annular capacitive rings. The sensor of the present invention also provides a constant output when a fixed torque is applied to the shafts and both shafts rotate through multiple 360° degree turns along the center axis.

There is nothing in either of the secondary references that suggests shielding the dielectric disk with a cage comprising a pair of apertured disks. However, even if a hindsight reconstruction were made based upon the combined teachings of the secondary references of Kovacich *et al.* and Takahashi based on reading the Applicants' invention, one skilled in the art would still not come up with the presently claimed invention for the reasons set forth above in reference to Montagu *et al.*

In view of the foregoing amendments to the claims and the remarks, Claims 1-4 and 6-8 are now believed to be in an allowable condition. If the Examiner has any questions concerning this amendment, please contact the undersigned attorney.

Respectfully submitted,

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9

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